MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
UNIVERSITY OF CAMBRIDGE LOCAL EXAMINATIONS SYNDICATE
General Certificate of Education Ordinary Level

CANDIDATE NAME

CENTRE NUMBER | S | | | | |

INDEX NUMBER | | | | |

Paper 3 Chemistry

October/November 2013

1 hour 15 minutes

Candidates answer on the Question Paper.

Additional Materials: Answer Paper.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section B
Answer any **two** questions.
Write your answers on the lined paper provided and, if necessary, continue on separate answer paper.

A copy of the Data Sheet is printed on page 15.
A copy of the Periodic Table is printed on page 16.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Section A

Answer **all** the questions in this section.

Write your answers in the spaces provided on the question paper.

1 **(a)** Clean air is a mixture of gases. Name **two** of these gases.

1. .....

2. .....

[2]

(b) On cooling, the gases in clean air may liquefy. Describe what happens to the spacing and movement of the particles in these gases as they become liquids.

changes to spacing

.....

changes to movement

.....

[2]

2 **(a)** Complete Table 2.1 by filling in the **five** blank boxes.

Table 2.1

substance	chemical formula	solubility in water	acidic or alkaline or neutral	colour of solution with Universal Indicator
calcium chloride	$CaCl_2$	soluble	neutral	
sulfuric acid		soluble	acidic	
potassium carbonate	K_2CO_3	soluble	alkaline	
lead(II) carbonate	$PbCO_3$	insoluble		
calcium carbonate		insoluble		

[5]

(b) When two of the substances in Table 2.1 are mixed together in solution they form a precipitate of calcium carbonate.

(i) Name these **two** substances.

1. .....

2. .....

[1]

(ii) What **three** processes would you use to obtain a pure sample of calcium carbonate from the result of this mixing?

1. .....

2. .....

3. .....

[3]

3 In Fig. 3.1, **A**, **B**, **C**, **D**, **E** and **F** represent the particles in different substances.

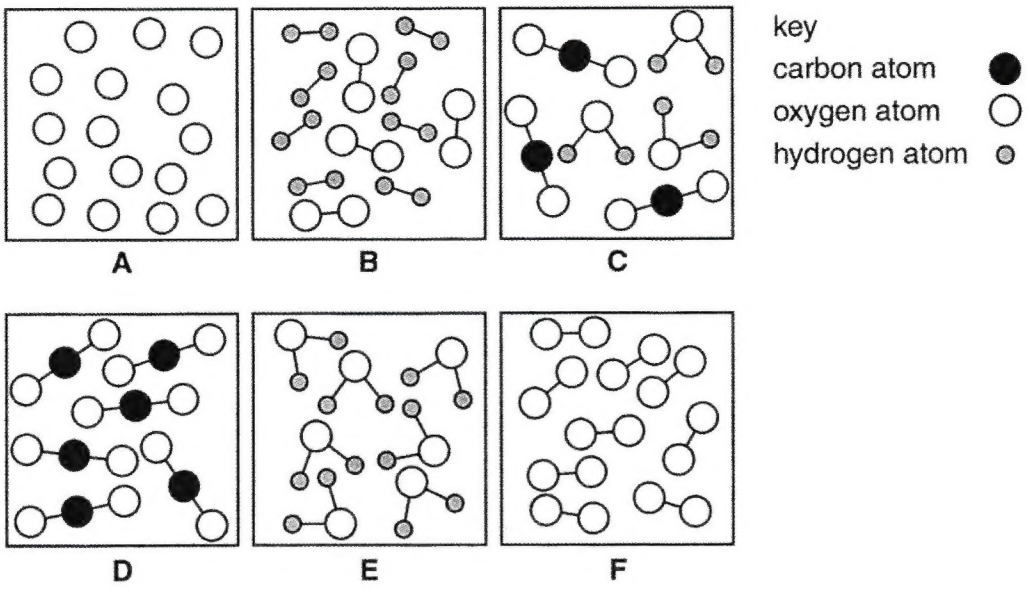


Fig. 3.1

Which one of **A**, **B**, **C**, **D**, **E** and **F** *best* represents

(a) pure carbon dioxide, ...

(b) pure oxygen, ...

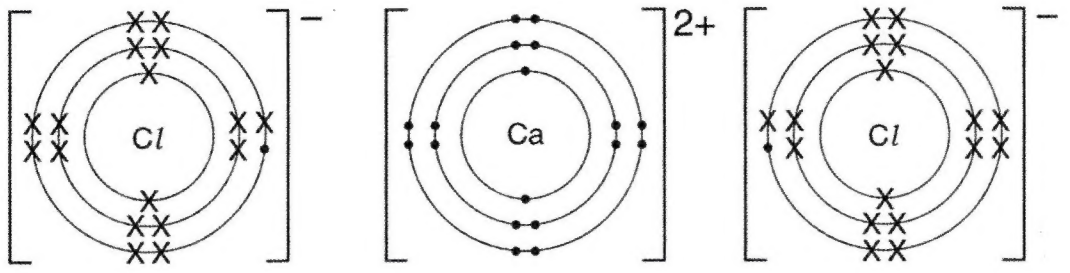
(c) a mixture of compounds, ...

(d) a mixture of elements, ...

(e) the products of burning ethanol in oxygen? .....

[5]

4 Fig. 4.1 shows the electronic structures of the ions in calcium chloride.



chloride ion calcium ion chloride ion

Fig. 4.1

(a) When calcium reacts with chlorine, neutral calcium atoms form calcium ions, each with a 2+ charge.

Use Fig. 4.1 to explain **how** and **why** this change has taken place.

.....

.....

.....

.....

.....[3]

(b) Solid and molten calcium chloride have different electrical conductivities.

Use the information in Fig. 4.1 and your knowledge of kinetic particle theory to explain this difference.

.....

.....

.....

.....[2]

(c) Write the ionic equation for the formation of the ions in calcium chloride solution.
State symbols are **not** required.

.....[2]

5 **(a)** A solution of nitric acid, HNO_3, has a concentration of $126\,g/dm^3$.

(i) Calculate the relative molecular mass of nitric acid.

[Relative atomic masses: A_r: H, 1; N, 14; O, 16]

relative molecular mass = ...[1]

(ii) Calculate the concentration of the solution in mol/dm^3.

concentration = ... mol/dm^3 [1]

(b) Magnesium carbonate reacts with nitric acid as follows:

$$MgCO_3 + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2O + CO_2$$

(i) How many moles of magnesium carbonate react with 1.0 mol of nitric acid?

number of moles of magnesium carbonate = ...[1]

(ii) How many moles of magnesium carbonate react with $500\,cm^3$ of $10\,mol/dm^3$ nitric acid?

number of moles of magnesium carbonate = ...[1]

(c) Another nitric acid solution is made by diluting 1.0 mol to make $2\,dm^3$ of solution. What is the concentration of this solution in mol/dm^3?

concentration of nitric acid solution = ... mol/dm^3 [1]

6 Fig. 6.1 describes the reactions of two colourless solutions, **G** and **H**.

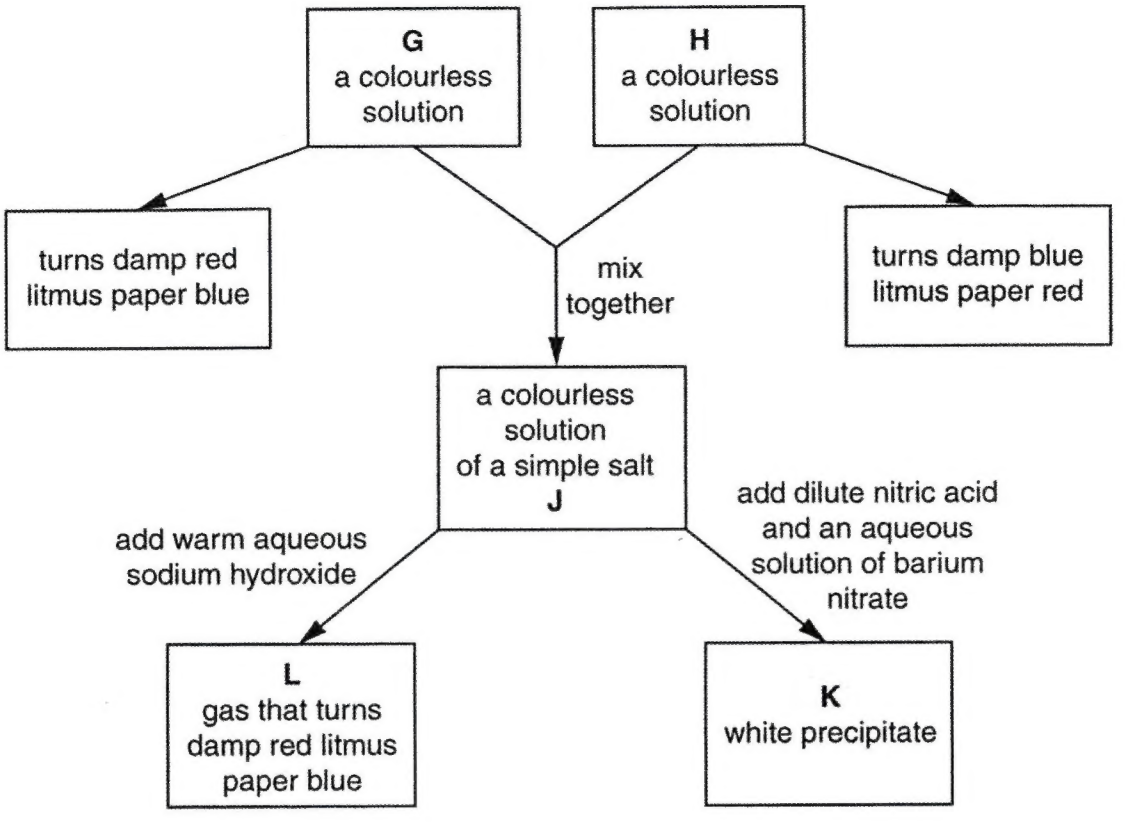


Fig. 6.1

(a) Name **L**, **K**, **J**, **H** and **G**.

L .....

K .....

J .....

H .....

G .....

[5]

(b) Write an equation for any **one** of the reactions that are described within Fig. 6.1. State symbols are **not** required.

.....[2]

7 The decomposition of hydrogen peroxide solution to produce oxygen is speeded up by mixing the solution with a black powder. The total volume of gas produced can be measured at fixed intervals of time.

(a) How would you show this gas to be oxygen?

.....

.....[1]

(b) Complete Fig. 7.1 to show how the volume of gas can be collected and measured every few seconds.

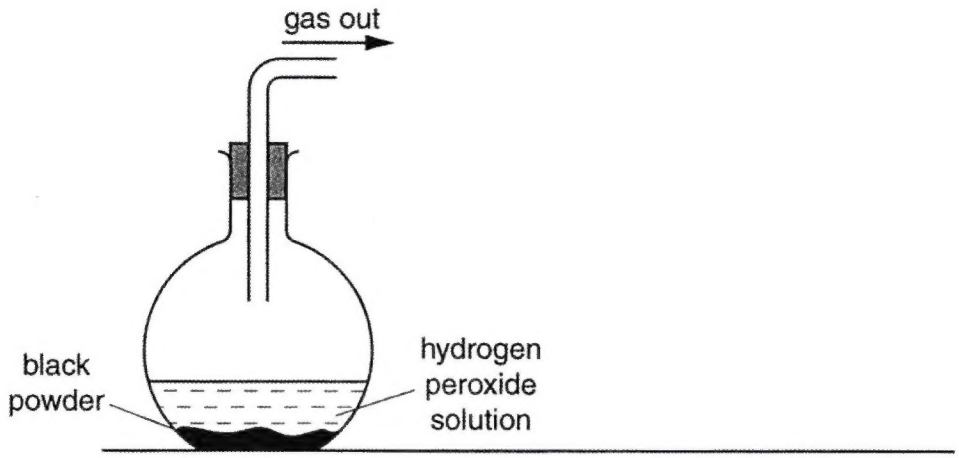


Fig. 7.1

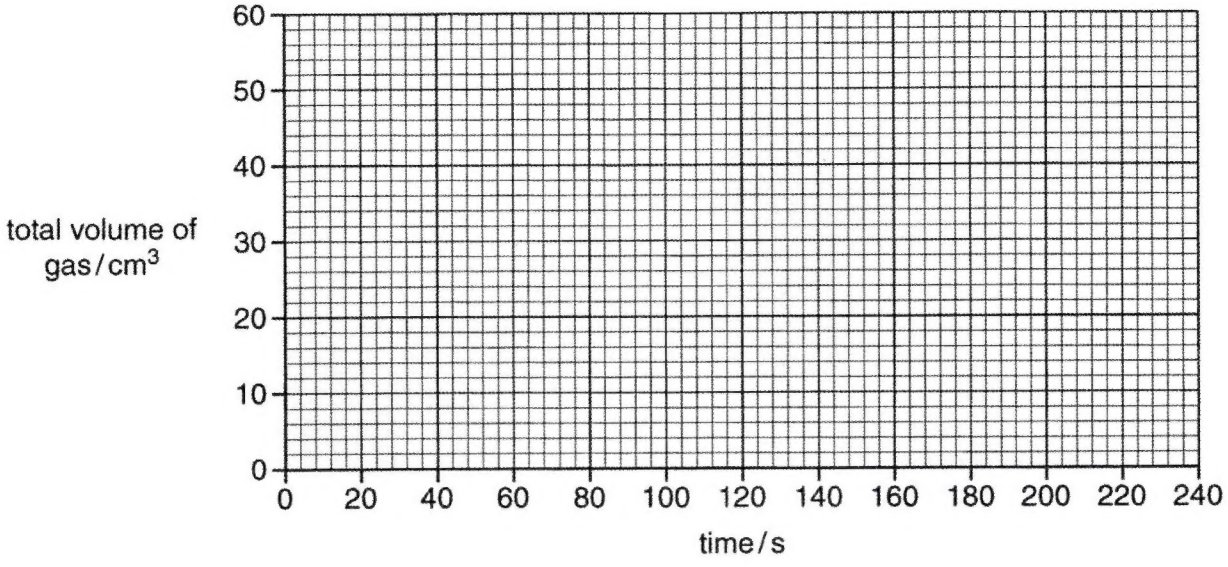
[2]

(c) The results of this experiment are shown in Table 7.1.

Table 7.1

time/s	0	20	40	60	140	180	200	220
total volume of gas/cm^3	0	14	25	32	48	50	50	50

(i) Plot these results on the graph paper below and draw a line of best fit.



[2]

(ii) Why were no further measurements taken after 220 seconds?

.....

.....[1]

(iii) Indicate on your graph how to estimate the volume of gas evolved after 100 seconds. Record your result below.

volume of gas evolved = ... cm^3 [1]

(iv) Calculate the average speed of reaction in cm^3/s for the first 100 seconds.

average speed of reaction = ... cm^3/s [1]

Section B

Answer any **two** questions from this section.

Write your answers on the lined paper provided and, if necessary, continue on separate answer paper.

8 **(a)** Organic compounds are placed in an homologous series.

(i) Give **two** general properties of an homologous series.

(ii) Write the general formula for the homologous series of alkanes.

(iii) Name and write the chemical formula for the first member of the alkanes.

[5]

(b) The alkenes include ethene, C_2H_4. This compound undergoes addition polymerisation to form addition polymers.

(i) Use the structural formula of ethene to explain how it can form addition polymers.

(ii) Write an equation for the addition polymerisation of ethene. State symbols are **not** required.

[5]

9 In the early 19th century a chemist, Frederich Wöhler, isolated aluminium metal. At a high temperature he reacted potassium, K, with aluminium chloride, $AlCl_3$, to form potassium chloride, KCl, and aluminium, Al. The **ionic** equation for the reaction is:

$$Al^{3+} + 3K \longrightarrow 3K^{+} + Al$$

Today's chemists would classify this reaction as both *exothermic* and *redox*.

(a) **(i)** Explain the term *exothermic* and, with reference to this reaction, the term *redox*.

(ii) Why was it essential that Wöhler kept water away from his reacting chemicals?

(iii) Explain why he used the dangerous and expensive potassium to prepare aluminium rather than the safe and cheaper copper.

[6]

(b) Give the balanced chemical equation for the reaction of aluminium chloride and potassium. Use this equation to determine the mass of aluminium chloride needed to produce 54 g of aluminium metal.

[Relative atomic masses: A_r: Al, 27; Cl, 35.5; K, 39] [4]

10 A Periodic Table is on page 16. Sodium has a proton number of 11.

(a) The Periodic Table lists the elements in groups and periods. An inspection of the electronic structure of an element's atom can give its group and period. Explain this using sodium as an example. You may draw a diagram if it helps your answer. [2]

(b) Sodium and the element of proton number 12 have similar chemical reactions. Describe **two** of these similar reactions. Write a chemical equation for **one** of the reactions you have described. Include state symbols. [5]

(c) Sodium and the element of proton number 10 have very different chemical reactivities. Use their electronic structures to explain this difference. [3]

35. (A)

Recycled copper contains a higher percentage of copper than copper ore. Copper obtained from recycling will therefore be purer than copper extracted from its ore.

36. (C)

Lightning causes the formation of oxides of nitrogen. These oxides are acidic and mix in rain water to give acid rain. Carbon monoxide is produced from the incomplete combustion of fossil fuels and causes suffocation when inhaled in excessive amounts. Sulfur dioxide is produced from volcanoes and causes acid rain.

37. (A)

All compounds are alkanes and share the general formula, C_nH_{2n+2}. Members of a homologous series share the same chemical properties but have different physical properties. The physical properties gradually change as the number of carbon atoms (n) changes.

EXAM TIP:

The general formula of each compound can be found based on its chemical formula.

38. (D)

Vegetable oil is polyunsaturated, which means that it has many C=C bonds which can undergo addition reaction to form margarine. Ethene is unsaturated but only has one C=C bond.

EXAM TIP:

A polyunsaturated substance contains multiple C=C bonds.

39. (B)

Ethanol cannot be converted to propanol directly and will require multiple steps to obtain propanol. Ethanol undergoes oxidation reaction to form ethanoic acid. Ethene undergoes hydration with water to form ethanol. Glucose is fermented to form ethanol and carbon dioxide.

EXAM TIP:

Propanol cannot be obtained by a single chemical reaction with ethanol.

40. (D)

The decolourisation of bromine water indicates the presence of C=C bonds. The reaction of sodium carbonate indicates the presence of –COOH group. Therefore compound Z is (D).

EXAM TIP:

Bromine water is used to test for unsaturated compounds and aqueous sodium carbonate is used to test for H^+ ions.

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Section A

1. **(a)** Nitrogen

Oxygen

EXAM TIP:

Clean air consists of approximately 78% nitrogen, 21% oxygen, 0.97% noble gases (mainly argon) and 0.03% carbon dioxide.

(b) changes to spacing: The spacing between particles decreases.

changes to movement: Particles move slower in liquid state than in gaseous state.

EXAM TIP:

Gaseous particles are spaced far apart from each other and move freely at high speeds, while liquid particles are packed closely together and slide past each other.

2. **(a)**

substance	chemical formula	solubility in water	acidic or alkaline or neutral	colour of solution with Universal Indicator
calcium chloride	$CaCl_2$	soluble	neutral	**green**
sulfuric acid	**H_2SO_4**	soluble	acidic	**red**
potassium carbonate	K_2CO_3	soluble	alkaline	**violet**
lead(II) carbonate	$PbCO_3$	insoluble		
calcium carbonate	**$CaCO_3$**	insoluble		

(b) **(i)** 1. Calcium chloride

2. Potassium carbonate

EXAM TIP:

Two soluble reactants are required for a precipitation reaction.

(ii) 1. Filter the precipitate

2. Wash with distilled water

3. Dry with filter paper

EXAM TIP:

The method of purification must be suitable for obtaining insoluble salt.

3. (a) D

EXAM TIP:

The chemical formula of carbon dioxide is CO_2.

(b) F

EXAM TIP:

The chemical formula of oxygen is O_2.

(c) C

EXAM TIP:

A compound consists of two or more elements.

(d) B

EXAM TIP:

An element consists of only one type of atom.

(e) C

EXAM TIP:

Complete combustion of an alcohol produces CO_2 and H_2O.

4. (a) Each calcium atom donates two electrons to two chlorine atoms, with the chlorine atoms accepting one electron each. In the process, the calcium atom becomes an ion with charge 2+. This happens so that the atom can attain a stable electronic structure of 8 valence electrons.

EXAM TIP:

A 2+ charge indicates that 2 electrons are given away.

(b) In solid calcium chloride, the ions are held in the ionic lattice and can only vibrate about their fixed positions, so there are no free-moving ions to conduct electricity.

In molten calcium chloride, the ions are free to slide past each other, allowing for the conduction of electricity.

EXAM TIP:

A substance conducts electricity if it has mobile charge carriers.

(c) $CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$

EXAM TIP:

Ionic equations are chemical equations that show the reactions involving ions.

5. (a) (i) Molar mass of $HNO_3 = 1 + 14 + 16 \times 3$

$= \underline{63}$

(ii) Concentration of HNO_3 in mol / dm^3

$= 126 \div 63$

$= \underline{2 \text{ mol / dm}^3}$

EXAM TIP:

$$\text{Concentration (mol/dm}^3\text{)} = \frac{\text{Concentration of solution in g / dm}^3}{\text{Molar mass of reactant in g / mol}}$$

(b) (i) Number of moles of $MgCO_3$

$= 1 \div 2$

$= \underline{0.5 \text{ mol}}$

(ii) Number of moles of HNO_3 present

$= \frac{500}{1000} \times 10$

$= 5$ mol

1 mole of HNO_3 reacts with 0.5 moles of $MgCO_3$.

Number of moles of $MgCO_3$ required

$= 5 \times 0.5$

$= \underline{2.5 \text{ mol}}$

EXAM TIP:

2 moles of HNO_3 react completely with 1 mole of $MgCO_3$.

(c) Concentration of HNO_3 solution

$= 1 \div 2$

$= \underline{0.5 \text{ mol / dm}^3}$

6. (a) L Ammonia gas

K Barium sulfate

J Ammonium sulfate

H Sulfuric acid

G Aqueous ammonia

EXAM TIP:

Litmus paper is used to identify if the solution is an acid or an alkali; warm aqueous sodium hydroxide is used to identify the anion; acidified aqueous barium nitrate is used to identify the cation.

(b) Any one of the following:

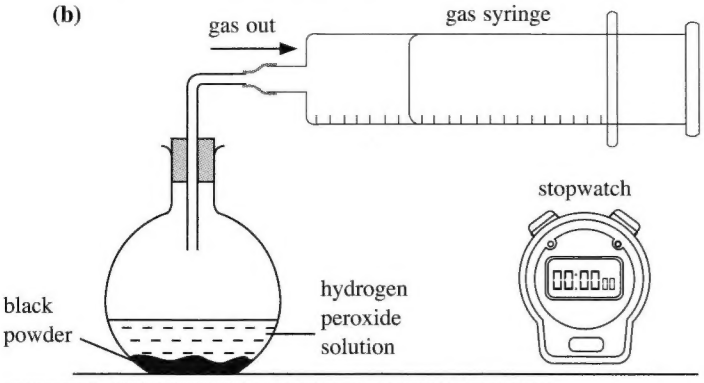
$H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$

$Ba(NO_3)_2 + (NH_4)_2SO_4 \rightarrow BaSO_4 + 2NH_4NO_3$

$(NH_4)_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2NH_3 + 2H_2O$

7. **(a)** Place a glowing splint at the mouth of the test-tube containing the gas. The glowing splint reignites if the gas is oxygen.

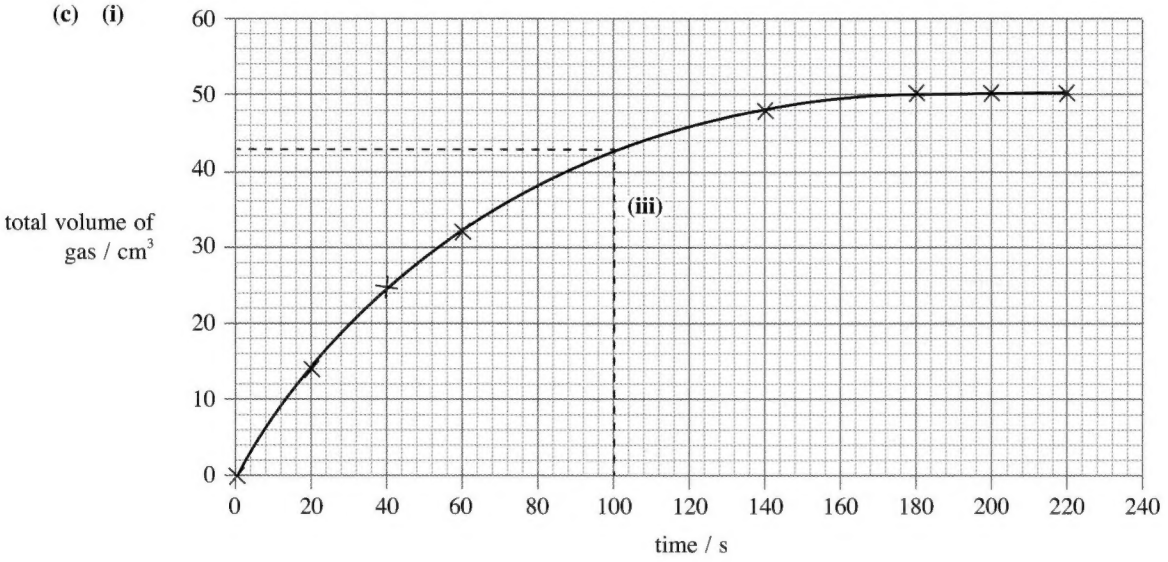
(b)



EXAM TIP:

A gas syringe is used to accurately measure the volume of gas.

(c) **(i)**



(ii) Hydrogen peroxide has been completely decomposed and no more oxygen gas is produced.

EXAM TIP:

After 180s, the total volume of gas collected remained constant, indicating that no more gas is produced.

(iii) 43 cm^3

(iv) Average speed of reaction

= Total volume of gas produced ÷ Total time taken

= 43 ÷ 100

= 0.43 cm^3 / s

EXAM TIP:

$$\text{Average speed of reaction } (cm^3/s) = \frac{\text{Total volume of gas } (cm^3)}{\text{Total time taken (s)}}$$

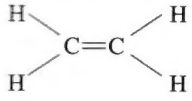
Section B

8. **(a)** **(i)** Compounds in a homologous series have the same general formula and functional group.

(ii) C_nH_{2n+2}

(iii) Methane, CH_4

(b) **(i)**



Ethene has C=C bond, which can form bonds with other molecules or atoms by addition. The ethene molecules are joined together at the C=C bonds to form a long chain of polymer.

(ii) $nC_2H_4 \rightarrow +CH_2-CH_2+_n$

EXAM TIP:

Poly(ethene) is produced through the addition polymerisation of ethene.

9. **(a)** **(i)** An *exothermic* reaction releases energy to the surroundings. A *redox* reaction is where both oxidation and reduction take place. In this case, Al^{3+} is reduced to form Al while K is oxidised to form K^+.

(ii) Potassium reacts very readily with water. Exposure to water not only causes some reactants to be lost, it is also hazardous as potassium explodes upon contact with water.

(iii) The reaction requires a metal that is more reactive than aluminium. Since potassium is higher in the reactivity series than aluminium, it displaces aluminium ions from aluminium chloride. If copper is used, no reaction would occur as copper cannot displace aluminium ions.

EXAM TIP:

Relate the choice of reactants to the difference in reactivity and how metals can displace each other.

(b) $AlCl_3 + 3K \rightarrow Al + 3KCl$

Number of moles of Al metal $= \frac{54}{27}$

$= 2$ mol

1 mole of $AlCl_3$ is required for 1 mole of Al to be produced.

Number of moles of $AlCl_3$ required = 2 mol

Mass of $AlCl_3$ required = $2 \times (27 + 35.5 \times 3)$

$= 267$ g

EXAM TIP:

First, find the number of moles of Al using

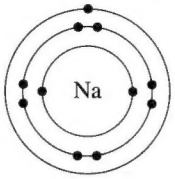
Number of moles of a substance $= \frac{\text{Mass(g)}}{\text{Molar mass}}$.

Then, calculate the mass of $AlCl_3$ using

Mass = Number of moles × Molar mass.

10. **(a)** The group of an element can be determined by the number of valence electrons it has. The period can be determined by counting the number of electron shells the element has.

Sodium has an electronic configuration of 2.8.1.



From this, we can tell that sodium belongs to Group I since it has one valence electron. It belongs to the third period since it has a total of three electron shells.

EXAM TIP:

Sodium is a Group I metal and belongs to Period 3.

(b) The element of proton number 12 is magnesium. Both are reactive metals.

They react with dilute hydrochloric acid to form a salt and hydrogen gas.

They also react with water to form a hydroxide and hydrogen gas.

Reaction with dilute hydrochloric acid:

$2Na(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2(g)$

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

Reaction with water:

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

$Mg(s) + 2H_2O(g) \rightarrow Mg(OH)_2(s) + H_2(g)$

(c) The element of proton number 10 is neon. Sodium has one valence electron while neon has eight valence electrons. Neon has a stable electronic configuration while sodium does not, hence neon is inert. Since sodium only needs to lose one electron to attain a stable electronic configuration, it is extremely reactive.

EXAM TIP:

Relate the difference in chemical reactivities to the number of valence electrons of each element.